

Calculator assisted determination of dilutions for continuous infusion ICU medications

JOSEF NEU, MD; COLLEEN MAHONEY; ALLEN D. WILSON, MD; THOMAS B. RICE, MD

A program has been developed for simplification of initial dilution calculations for several rapidly metabolized, vasoactive drugs that must be administered by continuous infusion. Included in the program is the capability for serial recalculation of drug dosage or iv flow rate as well as a checking routine to reduce errors. This program was developed primarily for the pediatric age group, where dilution of drugs into a small volume of diluent, accurate dosage calculations, and low iv flow rates are frequently necessary.

Critical care has recently been complicated by the increasing use of drugs that must be administered by continuous infusion because of their rapid metabolism and vasoactive character. The optimal dosage of these medications is usually determined by the patient's physiological response, thereby, often making multiple calculations necessary. The safe use of such drugs requires meticulous monitoring and accurately calibrated infusion pumps. In using these drugs, a potential for large errors in computation may result when these calculations are carried out by hand. Some ICUs have developed charts for administration of these drugs, which have been very helpful, but have the disadvantage that a constant dilution must be used. In pediatrics, this frequently makes the volume administered to the patient inordinately large, thus, potentially compromising the patient with fluid overload. The availability of the programmable bedside calculator, which can be readily operated by personnel without a computer background, has recently simplified the task of tedious mathematical calculations.

A program for the administration of several of these medications has been developed for the Hewlett-Packard 41C (HP-41C) calculator with printer. Use of this calculator with its alphanumeric capabilities can easily be mastered by personnel who do not have a computer background. The program we have developed is presently being used to simplify calculations for constant infusion of dopamine, nitroprusside, epinephrine, isoproterenol, prostaglandin E₁, and lidocaine.

From the Department of Pediatrics, The Medical College of Wisconsin and Milwaukee Children's Hospital, Milwaukee, WI.

Address requests for reprints to: Josef Neu, MD, Department of Pediatrics, Milwaukee Children's Hospital, 1700 West Wisconsin Avenue, Milwaukee, WI 53233.

METHODS

The program itself is seen in Figure 1. The execution of the program is seen in Figure 2. After passing the program cards through the card reader of the HP-41C, the program designated *ICM* is entered into the constant memory of the calculator. The program can then be recalled by use of the letters *ICM* or the entire procedure simplified by utilizing the *USER* mode of the HP-41C and assigning the program to be recalled by the use of a single key.

On successful initiation of the program, the user is prompted by "DRUG ID." At this point, the user then enters the first two letters of the generic drug name. For example: *EP* for epinephrine. If the drug desired is not in file, "NONEXISTENT" will appear and the program must be reinitiated. If the desired drug is on file, the drug name and dosage range will be printed and the user prompted for the patient information, which includes the desired infusion dose in $\mu\text{g}/\text{kg}\cdot\text{min}$, the patient's weight in kg, the iv flow rate in ml/h, the medication concentration in mg/ml or $\mu\text{g}/\text{ml}$ in the ampul, and the total number of ml of the desired infusion to be made. These numeric values are entered with the *R/S* key as prompted. The program then calculates the appropriate number of ml of the drug from the ampul that is to be combined with diluent to obtain the previously determined final volume of infusion.

The user is then prompted by *R/D* or *D/R* indicating that serial recalculations will be performed depending on the input variable. The operator selects which input variable is desired by depressing the alpha keys; *RD* for obtaining iv flow rate from a change in dose or *DR* to obtain the dose rate from a change in iv rate. After the selection is made, the user is prompted to enter the appropriate numeric values with the *R/S* key. For example, *DR* would prompt for the intravenous flow rate in ml/h and then calculate the dosage in $\mu\text{g}/\text{kg}\cdot\text{min}$ that would be delivered at that rate. Should the user not wish to perform serial recalculations but wish to calculate another drug, the program may be reinitiated by depressing *NO*.

If the dose entered or the serial recalculation results in an actual dosage that would fall outside of the established dosage range, the user is alerted by an audible signal and queried. Should the operator then choose to correct the calculation, the keys *NO* are depressed and the correct

01*LBL "ICM"	65 "DOSE RANGE="	120*LBL 04	170*LBL 31	243*LBL 42
02*LBL 00	66 ACA	121 "CN MED UG/CC"	179 RCL 12	244 SF 10
03 CF 09	67 PRBUF	122 PROMPT	180 RCL 13	245 ADV
04 CF 10	68 FIX 1	123 STO 03	181 XYY?	246 "RATE FROM DOSE"
05 CF 11	69 .05	124 "CN MED "	182 GTO 32	247 PRA
06 ADV	70 RCL 14	125 XEQ 24	183 RCL 13	248 ADV
07 CF 05	71 X<Y?	126 "/CC="	184 RCL 14	249 "DOSE UG/KG/M"
08 AON	72 FIX 3	127 ACA	185 XYY?	250 PROMPT
09 "DRUG ID?"	73 ACX	128 RCL 03	186 GTO 32	251 STO 10
10 PROMPT	74 "--	129 ACX	187 GTO 33	252 STO 13
11 ASTO 08	75 ACA	130 PRBUF	188*LBL 32	253 XEQ 22
12 CLA	76 FIX 1	131 1000	189 "NO"	254 .05
13 AOFF	77 RCL 12	132 /	190 ASTO Y	255 RCL 10
14 GTO IND 08	78 ACX	133 STO 03	191 CLA	256 X<Y?
15*LBL "DO"	79 CLA	134*LBL 05	192 BEEP	257 FIX 3
16 "DOPAMINE"	80 " "	135 "CC SOLN"	193 AON	258 ACX
17 5	81 XEQ 24	136 PROMPT	194 "Y OR NO ?"	259 PRBUF
18 STO 14	82 "/KG/M"	137 STO 04	195 PROMPT	260 FIX 2
19 20	83 ACA	138 XEQ 23	196 ASTO X	261 GTO 31
20 STO 12	84 PRBUF	139*LBL 11	197 CLA	262*LBL 36
21 GTO 21	85 ADV	140 RCL 00	198 AOFF	263 RCL 10
22*LBL "EP"	86*LBL 01	141 RCL 04	199 X=Y?	264 RCL 05
23 "EPINEPHRINE"	87 SF 09	142 .06	200 GTO 34	265 *
24 .1	88 FIX 2	143 *	201*LBL 33	266 RCL 06
25 STO 14	89 "DOSE UG/KG/M"	144 *	202 FS?C 09	267 /
26 1	90 PROMPT	145 RCL 03	203 GTO 02	268 STO 09
27 STO 12	91 STO 01	146 /	204 FS?C 10	269 "IV RATE CC/H"
28 GTO 21	92 STO 13	147 STO 05	205 GTO 36	270 XEQ 23
29*LBL "IS"	93 XEQ 22	148 RCL 01	206 FS?C 11	271 ADV
30 .1	94 .05	149 RCL 02	207 GTO 35	272 GTO 37
31 STO 14	95 RCL 01	150 /	208*LBL 34	273*LBL 22
32 1	96 X<Y?	151 *	209 FS?C 09	274 "DOSE "
33 STO 12	97 FIX 3	152 STO 06	210 GTO 01	275 XEQ 24
34 "ISOPROTERENOL"	98 ACX	153 FIX 2	211 FS?C 10	276 "/KG/M="
35 GTO 21	99 PRBUF	154 .05	212 GTO 42	277 ACA
36*LBL "LI"	100 GTO 31	155 RCL 06	213*LBL 41	278 RTN
37 20	101*LBL 02	156 X<Y?	214 SF 11	279*LBL 23
38 STO 14	102 FIX 1	157 FIX 3	215 ADV	280 ACA
39 50	103 "IV RATE CC/H"	158 ADV	216 "DOSE FROM RATE"	281 "--
40 STO 12	104 PROMPT	159 ACX	217 PRA	282 ACA
41 "LIDOCAINE"	105 STO 02	160 " CC "	218 ADV	283 ACX
42 GTO 21	106 XEQ 23	161 ACA	219 "IV RATE CC/H"	284 PRBUF
43*LBL "NI"	107*LBL 03	162 ASHF	220 PROMPT	285 RTN
44 .5	108 FIX 1	163 ARCL 10	221 STO 07	286*LBL 24
45 STO 14	109 "WT IN KG"	164 ACA	222 XEQ 23	287 ACA
46 12	110 PROMPT	165 ASHF	223 RCL 05	288 12
47 STO 12	111 STO 00	166 ARCL 11	224 1/X	289 ACCHR
48 "NITROPRUSSIDE"	112 XEQ 23	167 ACA	225 RCL 07	290 103
49 GTO 21	113 FS? 05	168 ASHF	226 RCL 06	291 ACCHR
50*LBL "PR"	114 GTO 04	169 ARCL 15	227 *	292 RTN
51 SF 05	115 "CN MED MG/CC"	170 ACA	228 *	293*LBL 25
52 .025	116 PROMPT	171 PRBUF	229 STO 08	294 ADV
53 STO 14	117 STO 03	172 "FROM AMPULE "	230 STO 13	295 ADV
54 .1	118 XEQ 23	173 ACA	231 XEQ 22	296 ADV
55 STO 12	119 GTO 05	174 "INTO SOLN"	232 .05	297 ADV
56 "PROSTAGLANDIN"		175 ACA	233 RCL 08	
57*LBL 21		176 PRBUF	234 X<Y?	
58 ACA		177 GTO 25	235 FIX 3	
59 ASTO 10			236 ACX	
60 ASHF			237 PRBUF	
61 ASTO 11			238 FIX 2	
62 ASHF			239 GTO 31	
63 ASTO 15			240*LBL 35	
64 PRBUF			241 ADV	
			242 GTO 37	
				298*LBL 37
				299 FIX 2
				300 "RD"
				301 ASTO 17
				302 "DR"
				303 ASTO 18
				304 AON
				305 "R/D, D/R, NO?"
				306 PROMPT
				307 ASTO X
				308 CLA
				309 AOFF
				310 ARCL 17
				311 ASTO Y
				312 CLA
				313 X=Y?
				314 GTO 42
				315 ARCL 18
				316 ASTO Y
				317 CLA
				318 X=Y?
				319 GTO 41
				320 GTO 00
				321 END

Fig. 1. Program.

DOPAMINE
DOSE RANGE=
5.0- 20.0 $\mu\text{g}/\text{KG}/\text{M}$

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 10.00
IV RATE CC/H= 3.0
WT IN KG= 5.0
CN MED MG/CC= 40.0
CC SOLN= 30.0

0.75 CC DOPAMINE
FROM AMPULE INTO SOLN

LIDOCAINE
DOSE RANGE=
20.0- 50.0 $\mu\text{g}/\text{KG}/\text{M}$

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 20.00
IV RATE CC/H= 5.0
WT IN KG= 15.0
CN MED MG/CC= 10.0
CC SOLN= 50.0

10.00 CC LIDOCAINE
FROM AMPULE INTO SOLN

information re-entered. If the user agrees with the calculated dosage outside of the variables and desires to proceed with the program, Y (yes) is entered.

SUMMARY

This programmed computation of drug dosages is intended to simplify patient care and reduce the possibility of errors in calculation of continuous drug infusion. The flexibility of solution preparation and serial recalculation of drug dose and iv flow rate which is crucial in pediatric critical care is augmented by this program. In addition, the relatively inexpensive nature of the programmable calculator enables it to be used in both large and small critical care units.

RATE FROM DOSE

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 17.00
IV RATE CC/H= 5.10

NITROPRUSSIDE
DOSE RANGE=
0.5- 12.0 $\mu\text{g}/\text{KG}/\text{M}$

EPINEPHRINE
DOSE RANGE=
0.1- 1.0 $\mu\text{g}/\text{KG}/\text{M}$

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 0.10
IV RATE CC/H= 5.0
WT IN KG= 15.0
CN MED MG/CC= 1.0
CC SOLN= 50.0

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 1.00
IV RATE CC/H= 5.0
WT IN KG= 5.0
CN MED MG/CC= 50.0
CC SOLN= 25.0

0.030 CC NITROPRUSSIDE
FROM AMPULE INTO SOLN

0.90 CC EPINEPHRINE
FROM AMPULE INTO SOLN

PROSTAGLANDIN
DOSE RANGE=
0.025- 0.1 $\mu\text{g}/\text{KG}/\text{M}$

DOSE FROM RATE

IV RATE CC/H= 6.70
DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 0.13

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 0.10
IV RATE CC/H= 5.0
WT IN KG= 5.0
CN MED $\mu\text{g}/\text{CC}$ = 50.0
CC SOLN= 25.0

ISOPROTERENOL
DOSE RANGE=
0.1- 1.0 $\mu\text{g}/\text{KG}/\text{M}$

3.00 CC PROSTAGLANDIN
FROM AMPULE INTO SOLN

DOSE $\mu\text{g}/\text{KG}/\text{M}$ = 0.10
IV RATE CC/H= 10.0
WT IN KG= 10.0
CN MED MG/CC= 0.2
CC SOLN= 50.0

1.50 CC ISOPROTERENOL
FROM AMPULE INTO SOLN

FIG. 2. Program execution.